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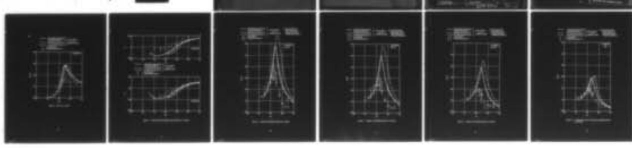

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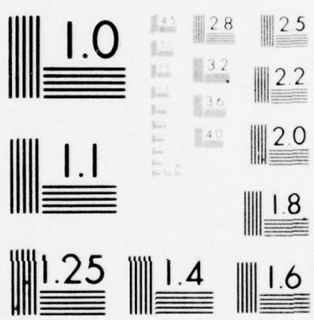

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DYNAMIC WATERLINE SEAKEEPING PREDICTIONS

FOR A FISHING VESSEL

R. M. WATKINS

N. K. BALES

FINAL REPORT

JULY 1976

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590

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16. Abstract

This report continues the work reported in report CG-D-5-76 titled "Validity of a Strip Theory - Linear Superposition Approach to Predicting Probabilities of Deck Wetness for a Fishing Vessel," dated November 1975.

This report examines the use of a dynamic waterline for strip theory motion computations for a full-hull fishing vessel. This vessel exhibited considerable trim, sinkage, and bow wave at high speed. Because of this, it was thought that the use of an experimentally determined high speed waterline could improve prediction accuracy. It is shown, however, that no improvement was obtained. It was concluded that computational errors introduced by the dynamic waterline were negligible compared to errors introduced by the full-hulled vessel's violation of strip theory assumptions.

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TABLE OF CONTENTS

	Page
ABSTRACT	1
ADMINISTRATIVE INFORMATION	1
INTRODUCTION	1
PROCEDURE AND RESULTS	2
CONCLUSIONS	3
REFERENCES	4

LIST OF FIGURES

Figure 1 - Body Plan of Vessel Investigated	5
Figure 2 - Calm Water Trim, Sinkage and Wave Profile at 15 Knots	6
Figure 3 - Pitch at 15 Knots	7
Figure 4 - Heave at 15 Knots	8
Figure 5 - Pitch-to-Wave and Heave-to-Wave Phases at 15 Knots	9
Figure 6 - Station 0.0 Relative Motion at 15 Knots	10
Figure 7 - Station 1.0 Relative Motion at 15 Knots	11
Figure 8 - Station 2.5 Relative Motion at 15 Knots	12
Figure 9 - Longitudinal Center of Buoyancy Relative Motion at 15 Knots	13

NOTATION

θ_A	Single amplitude of pitch in degrees
ν_M	Maximum wave slope in degrees
λ	Wavelength in metres
Z_A	Single amplitude of heave in metres
ζ_A	Single amplitude of wave in metres
L	Ship length between perpendiculars in metres
$\varepsilon_{\theta\zeta}$	Pitch-to-wave phase angle in degrees
$\varepsilon_{Z\zeta}$	Heave-to-wave phase angle in degrees
r_A	Single amplitude of ship-to-wave relative motion in metres

ABSTRACT

This report examines the use of a dynamic waterline for strip theory motion computations for a full-hull fishing vessel. This vessel exhibited considerable trim, sinkage, and bow wave at high speed. Because of this, it was thought that the use of an experimentally determined high speed waterline could improve prediction accuracy. It is shown, however, that no improvement was obtained. It was concluded that computational errors introduced by the dynamic waterline were negligible compared to errors introduced by the full-hulled vessel's violation of strip theory assumptions.

ADMINISTRATIVE INFORMATION

The work reported herein was sponsored by the United States Coast Guard (USCG). Amendment No. 2 to Military Interdepartmental Purchase Request Z70099-5-50646 was the funding document. At the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) the work was identified by Work Unit Number 1-1568-014.

INTRODUCTION

In November of 1975, DTNSRDC released the report "Validity of a Strip Theory-Linear Superposition Approach to Predicting Probabilities of Deck Wetness for a Fishing Vessel," Reference 1. This report concluded that strip theory was not generally applicable because of the incompatibility of the vessel's full hull form (see Figure 1) with state-of-the-art theory. However, it was suggested in the report that computations performed for the fishing vessel using the experimentally determined 15-knot waterline might improve predictions at 15 knots. This suggestion was based on the observation of a large bow wave, and trim and sinkage at high speeds. These phenomena caused a considerable change in the underwater body from that at zero knots. The zero-knot waterline was used for the original computations, as is customary.

In the interest of improving prediction techniques, the USCG sponsored an investigation into the effects of using a 'dynamic' waterline for strip theory computations. The investigation was conducted at DTNSRDC. This document describes the revised computations and the results thereof.

PROCEDURE AND RESULTS

All revised computations were made using the Frank Close-Fit Ship-Motion Computer Program (YF 17, see Reference 2) so that they would be directly comparable to the original computations in Reference 1.

Data from the Reference 1 experiment defined the trim, sinkage, and bow wave of the fishing vessel at 15 knots. These data are illustrated by Figure 2.

Two YF 17 computations with variations of waterline were made in an attempt to improve predictions of ship behavior. The first computation was made using the waterline resulting from experimentally measured values of trim and sinkage (3.5 degrees bow up and 0.457 metres (1.5 feet) down, respectively). This waterline is identified in Figure 2 as revised waterline #1.

The results of the first computation were *discouraging*. The quality of the predictions was less than that of the original computations for the static waterline. It can be seen in Figures 3, 4, and 6 through 9 that the predicted response magnitudes increased, and that an additional error in predicting peak frequencies was introduced. Pitch and heave phase angle predictions also degenerated as shown in Figure 5.

The computation for revised waterline #1 gave rise to an anomaly in ship hydrostatics. The displacement of the hull at this waterline was found to be 18 percent greater than the displacement reported in Reference 1 for the static waterline (461 versus 390 tonnes). Such a change in displacement was difficult to justify in the context of speed-related lift force.

In an attempt to resolve this anomaly, a second computation was performed using the vessel's wave profile (from measurements in calm water at 15 knots) as a waterline. Figure 1 identifies this waterline as revised waterline #2.

A displacement of 421 tonnes, representing an 8 percent increase with respect to the static case, was computed for revised waterline #2.

Response computations for revised waterline #2 produced results which were, for practical purposes, identical to those reported in Reference 1 for the static waterline. The comparison is shown by Figures 3 through 9. With respect to Figure 9, it should be noted that the longitudinal center of buoyancy was located at Station 5.2 for the static waterline, at Station 5.6 for revised waterline #1, and at Station 5.1 for revised waterline #2. The measurements shown apply to the static waterline longitudinal center of buoyancy.

CONCLUSIONS

Neither of the two revised waterlines used resulted in the hoped-for improvement in prediction quality. It can be said, therefore, that the dynamic waterline had a negligible influence on prediction capabilities when compared to other basic strip theory assumptions that were violated. Current strip theory assumes a slender hull form with its subsequent small effect on encountered wave patterns and slow rate of change of hydrodynamic phenomena in the longitudinal direction. The fishing vessel with a length to beam ratio of 3.3, high draft, and high Froude number operating range must consequently await state-of-the-art advances in theory before its performance in a seaway can be accurately predicted without recourse to experiments.

REFERENCES

1. Bales, N.K. et al., "Validity of a Strip Theory-Linear Superposition Approach to Predicting Probabilities of Deck Wetness for a Fishing Vessel," DTNSRDC Report SPD-643-01, November 1975.

2. Frank, W., and N. Salvesen, "The Frank Close-Fit Ship-Motion Computer Program," NSRDC Report 3289, June 1970.

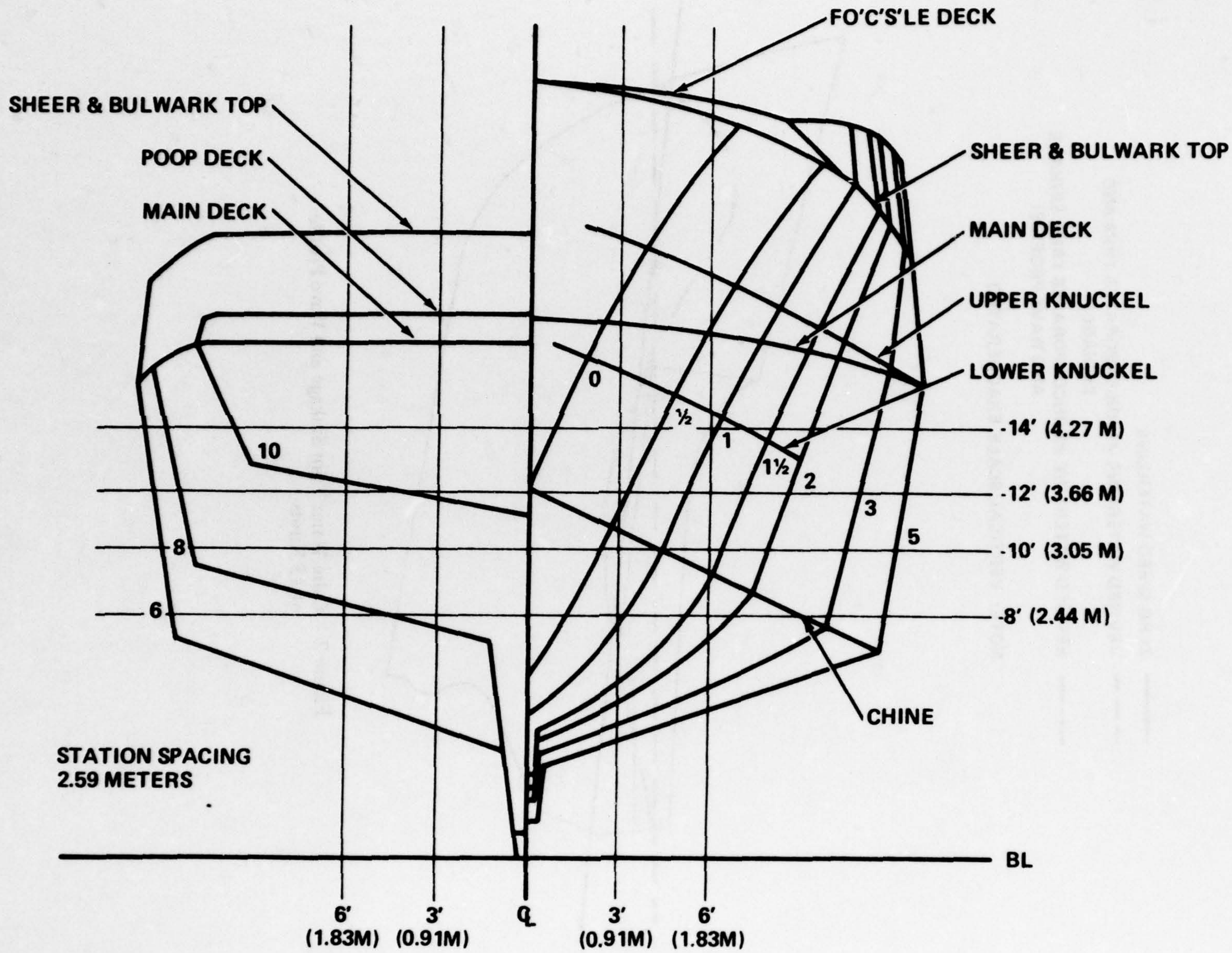

Figure 1 – Body Plan of Vessel Investigated

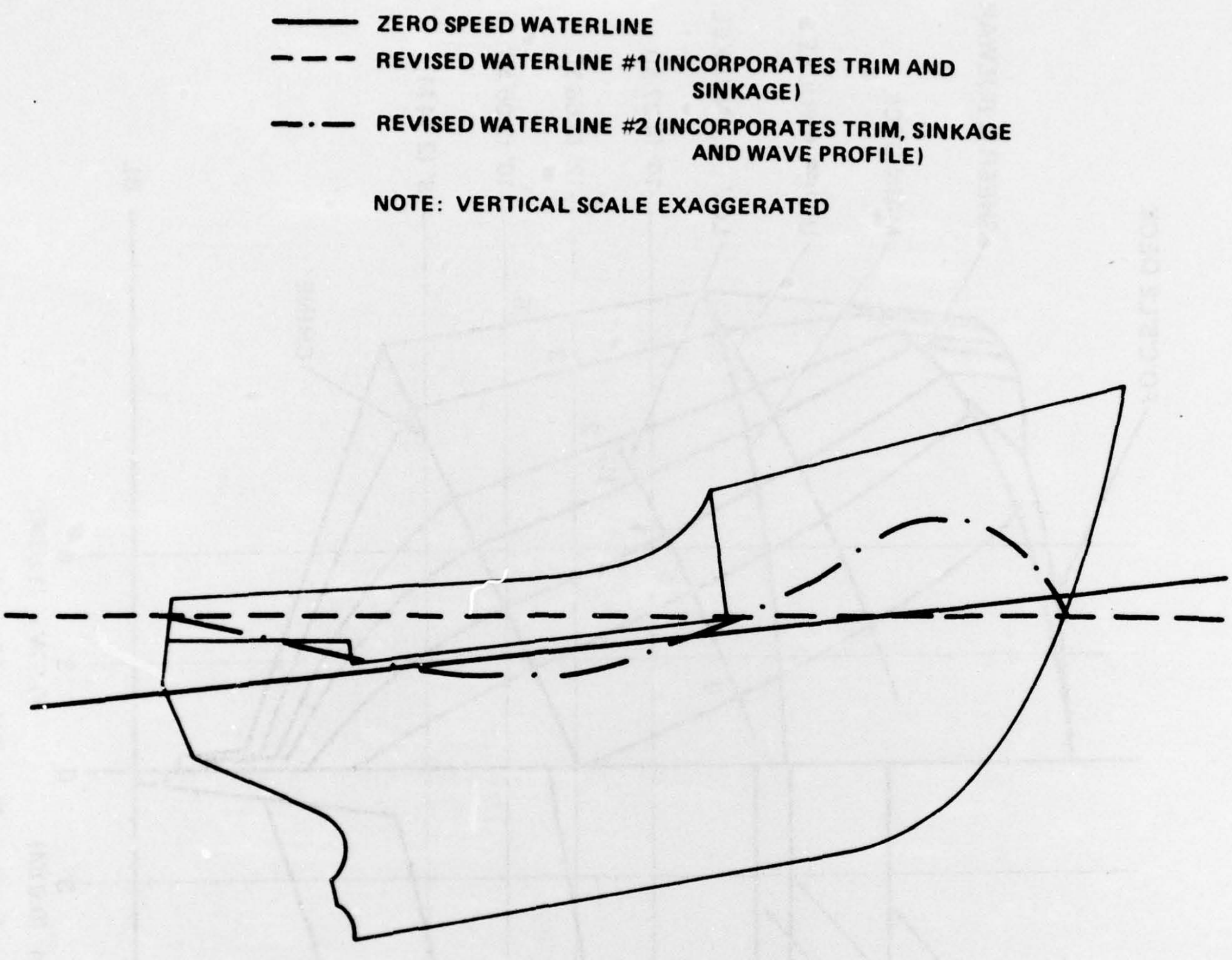

Figure 2 – Calm Water Trim Sinkage and Wave Profile at 15 Knots

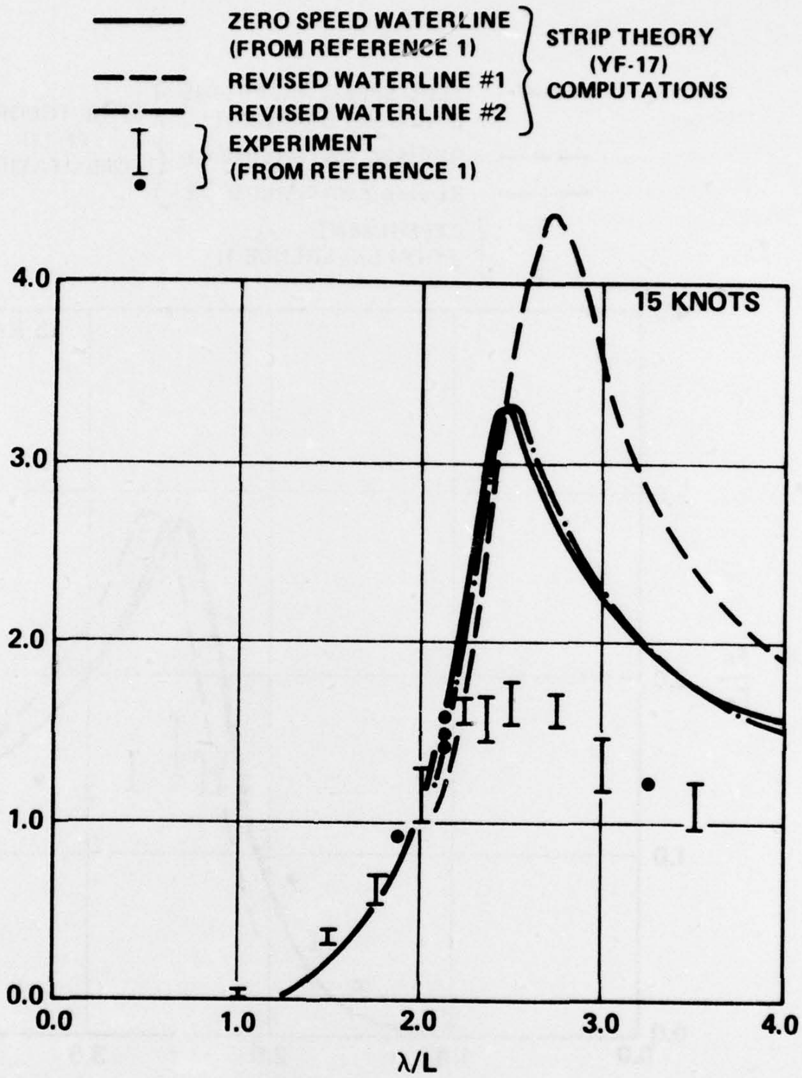

Figure 3 – Pitch at 15 Knots

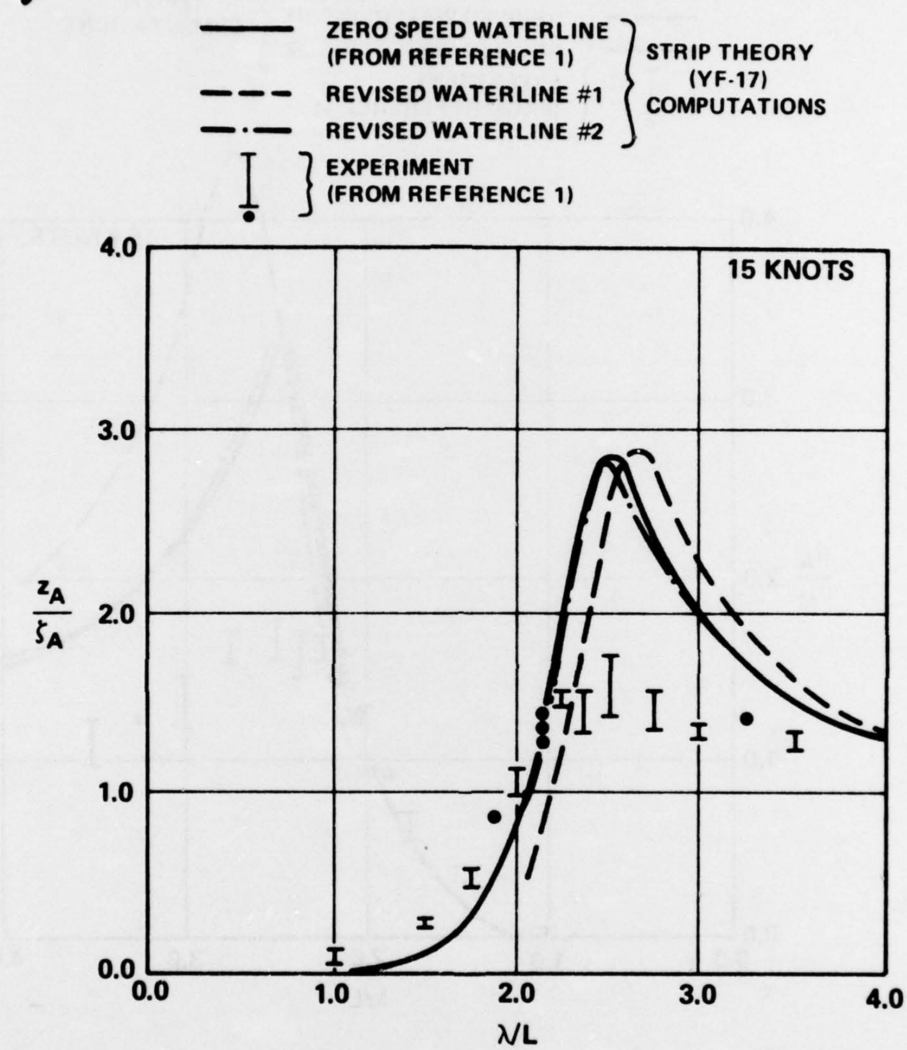

Figure 4 – Heave at 15 Knots

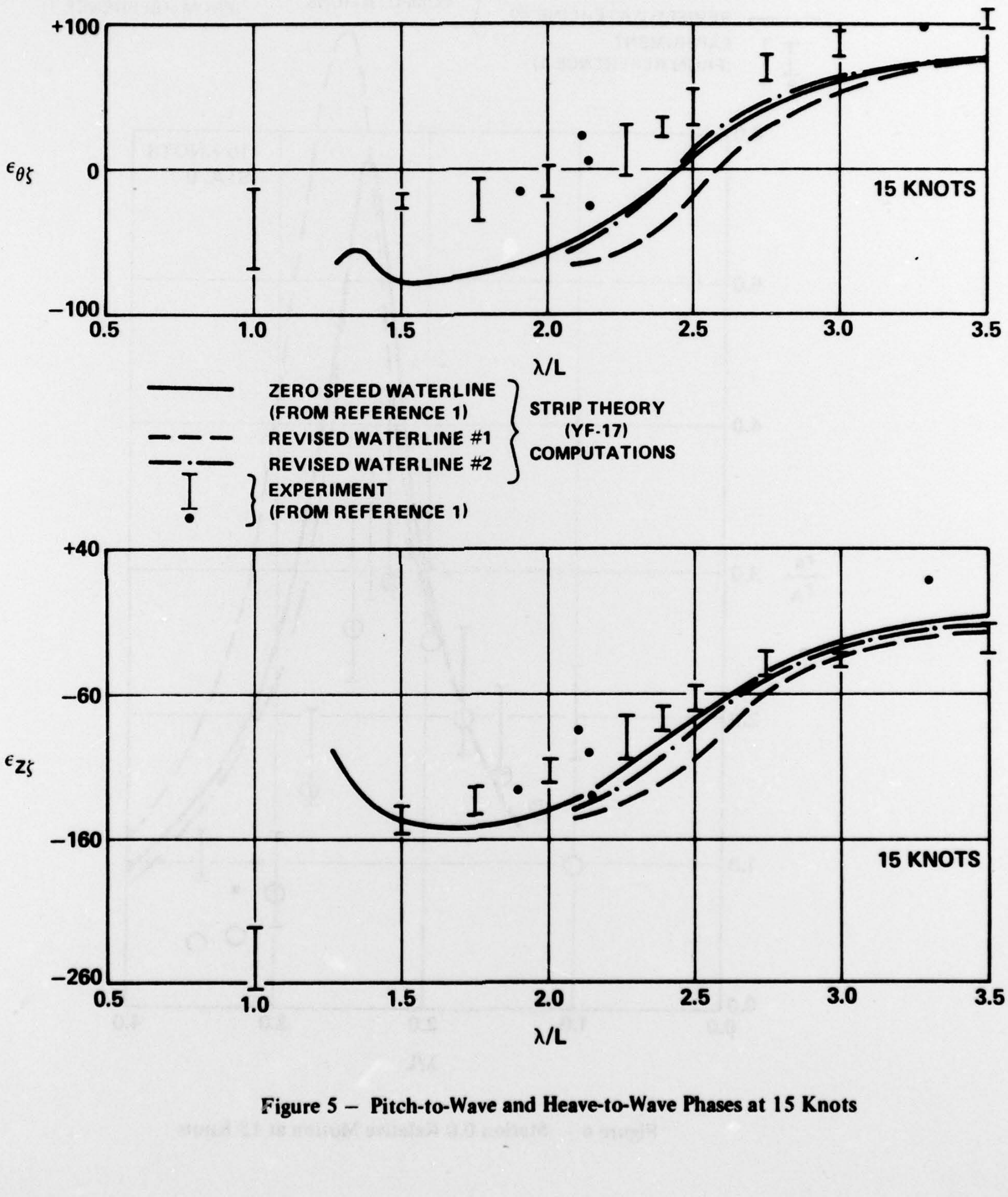

Figure 5 – Pitch-to-Wave and Heave-to-Wave Phases at 15 Knots

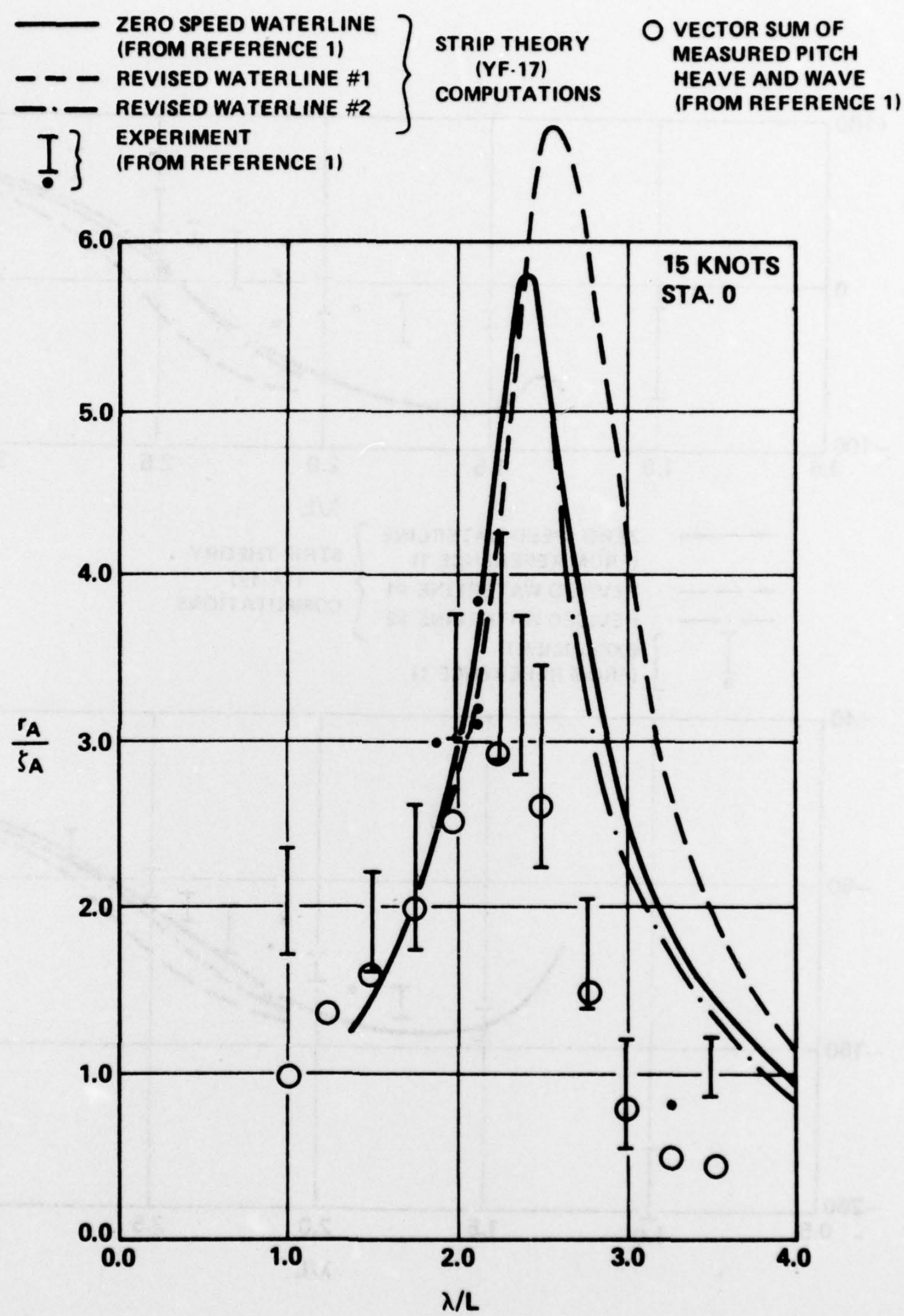

Figure 6 – Station 0.0 Relative Motion at 15 Knots

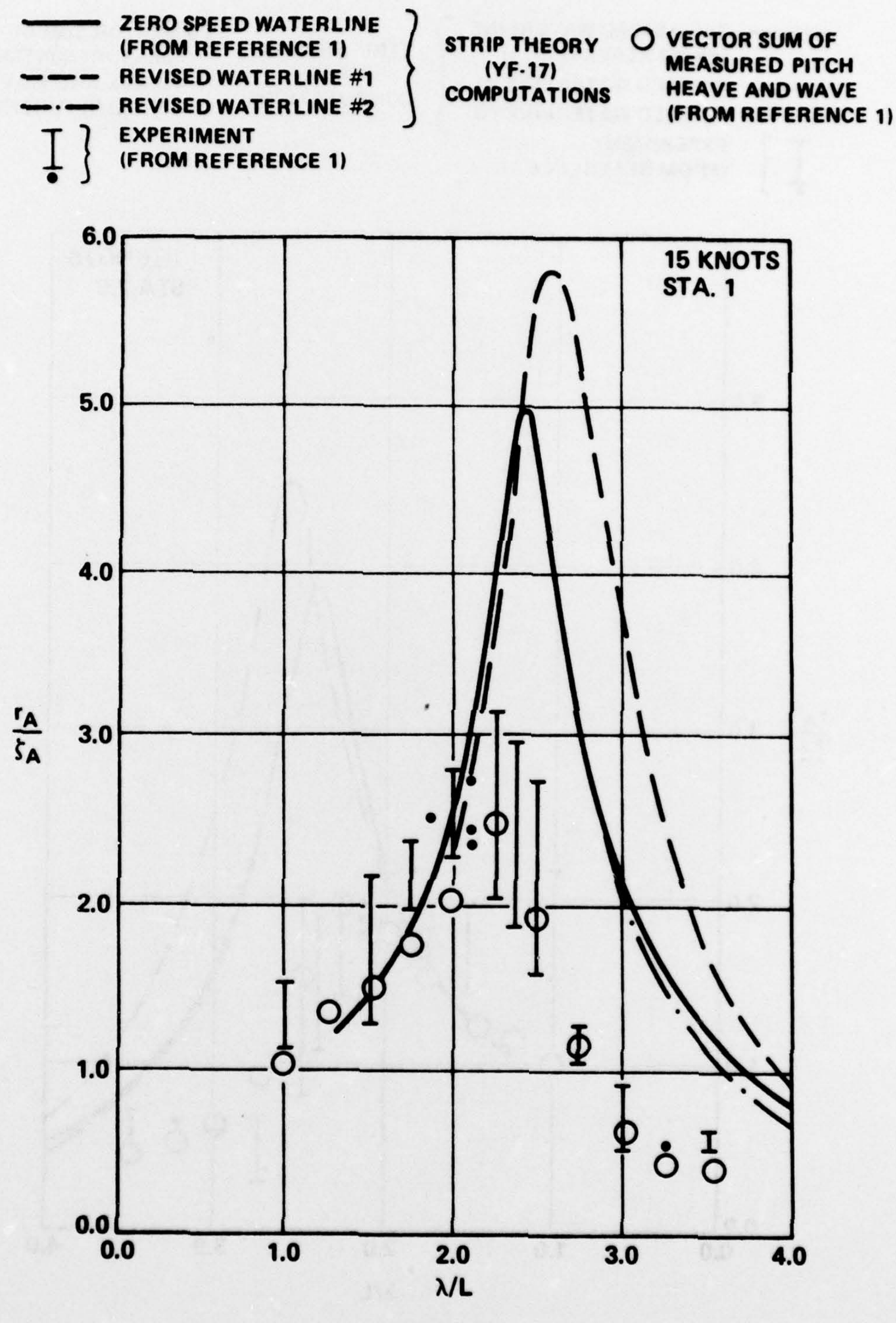

Figure 7 – Station 1.0 Relative Motion at 15 Knots

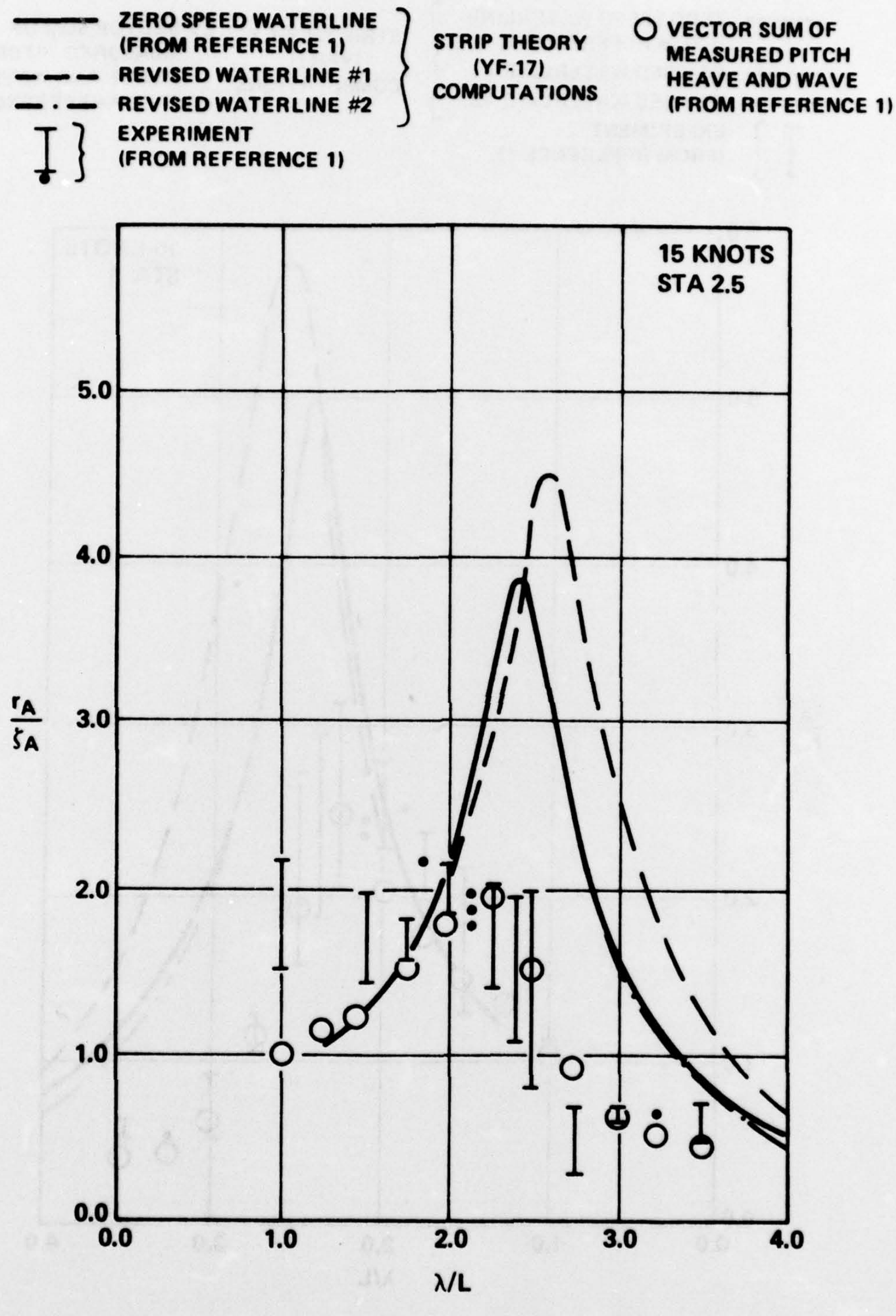

Figure 8 – Station 2.5 Relative Motion at 15 Knots

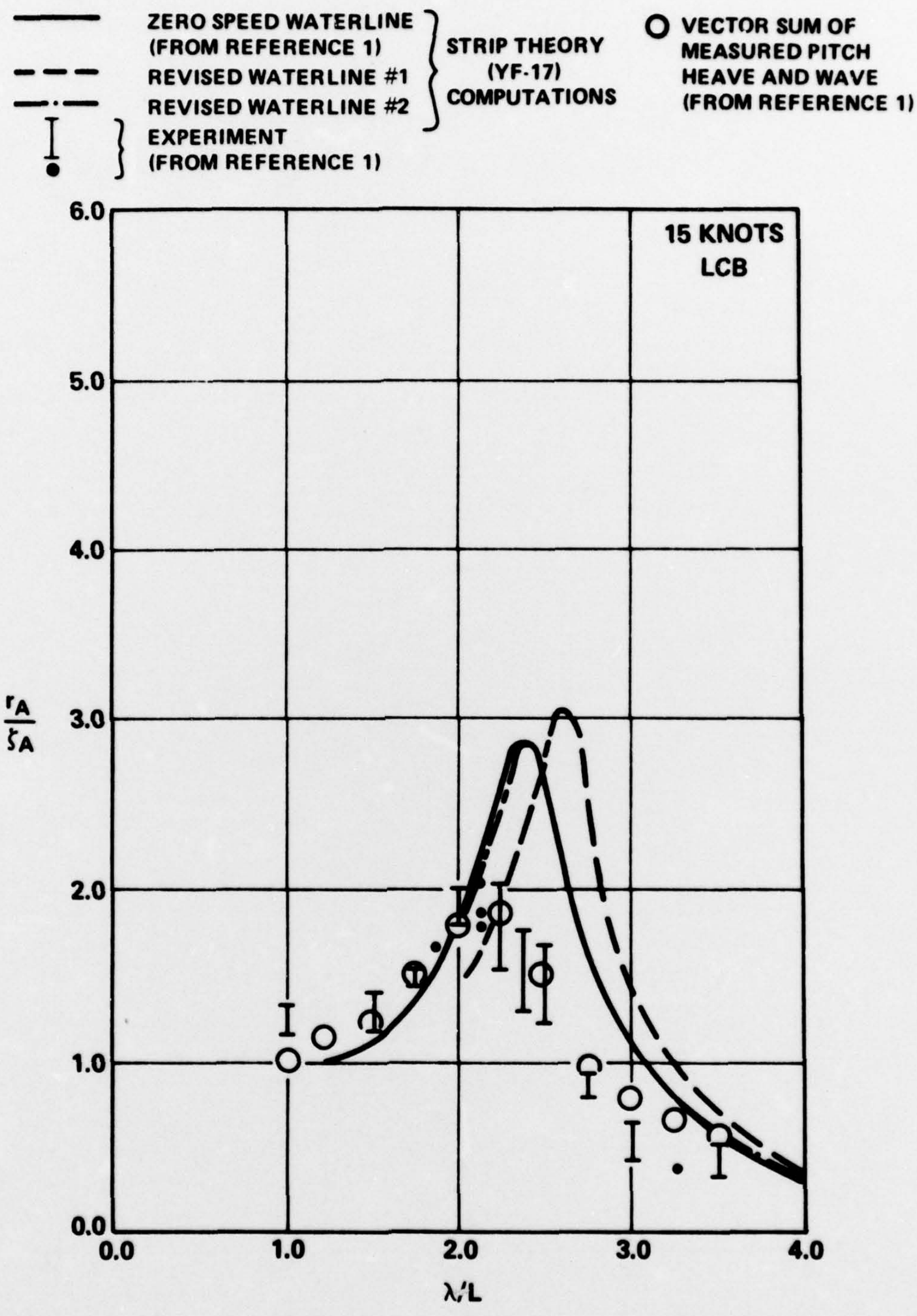

Figure 9 – Longitudinal Center of Buoyancy Relative Motion at 15 Knots